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L11: Entry 1 of 1 File: DWPI Aug 28, 2000

DERWENT-ACC-NO: 1993-396405
DERWENT-WEEK: 200044

TITLE: Material contg. 60-95 vol.% graphite plus aluminium@ alloy - used for piston mfr., obtd. by impregnation of graphite with molten alloy under high pressure

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PATENT-ASSIGNEE: TOKAI CARBON KK (TOJW)

PRIORITY-DATA: 1992JP-0172076 (June 5, 1992)

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ABSTRACTED-PUB-NO: DE 4318193A
BASIC-ABSTRACT:

A compound material suitable for piston mfr. has max. porosity 10% and is composed of 60-95 vol.% isotropic graphite impregnated with an Al-alloy. Also claimed is a process for prodn. of said material involving impregnation of isotropic graphide, porosity 5-40%., with molten Al-alloy under min. pressure of 100 kg/cm2. Pref. max. porosity of compound material is 2.0%. Pref. porosity of isotropic graphite is 8-25%.

USE/ADVANTAGE - A lightweight compound material with low thermal expansions and excellent mechanical properties used in mfr. of pistons for combustion engines.

ABSTRACTED-PUB-NO: DE 4318193A
EQUIVALENT-ABSTRACTS:

CHOSEN-DRAWING: Dwg.0/2

DERWENT-CLASS: L02 M26 P53 Q52 Q65
CPI-CODES: L02-J01; M22-G03K;

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(54) BASE MATERIAL FOR PISTON AND PRODUCTION THEREOF

(57)Abstract:

PURPOSE: To provide a graphite-aluminum alloy composite series base material for piston and a manufacturing method thereof having light wt. and providing low thermal expansion and also excellent material strength characteristic.

CONSTITUTION: This base material for piston is the graphite-aluminum series material dispersing the aluminum alloy in porous structure of isotropic graphite material and has the vol. ratio of the graphite possessed in this composite series material in the range of 60-95% and provides composition characteristic of ≤10% porosity of this material. In this method for manufacturing the base material for piston, the molten aluminum alloy is pressurized and impregnated to the isotropic graphite material having 5-40% porosity at ≥100kg/cm2 pressure.

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* NOTICES *

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention is lightweight and relates to the material for pistons and its manufacture method of the internal combustion engine which combines low thermal-expansion nature and the outstanding quality-of-the-material intensity.
[0002]
[Description of the Prior Art] The aluminium alloy (JIS AC8A and A4032 grade) of the aluminum-Si system containing comparatively a lot of silicon components is lightweight, and since it has the low-fever expansion coefficient, it is used abundantly as a material for pistons of an internal combustion engine from the former. However, since the still severer performance grant for the reduction in mpg, a high increase in power, the reduction in noise, etc. is demanded of the piston member and the temperature and the rotational frequency in an engine increase in connection with this in recent years, for the piston material made from an aluminium alloy, correspondence is difficult in property.
[0003] although it has the suitable peculiar property for the material for pistons of coefficient of thermal expansion of a graphite being small by low density, and there being lubricity and not producing an on-the-strength fall under an elevated temperature, the quality-of-the-material intensity itself is markedly boiled compared with a metallic material, and it has a fatal fault of a low For this reason, although there is no example applied to the material for pistons as a graphite simple substance, about a means to aim at an improvement of a piston performance, many researches are made by making it composite-ize with a metallic material using the peculiar property.
[0004] There is the method (distributed casting) of making the molten metal of the aluminium alloy currently indicated by the method (powder sintering process) or JP,57-124564,A which mixes and sinters a graphite powder to aluminium alloy powder which is indicated by JP,1-132736,A distribute a graphite powder, and casting in the typical multicomputer system which made the metallic material the aluminium alloy. However, its attention was not paid to these methods by the low-fever expansibility or the high temperature strength of a graphite by not setting it as the main purposes to give lubricity to the piston material of an aluminium alloy by addition of a graphite powder. Incidentally, the limitation of the graphite-powder addition in a powder sintering process is about 5 % of the weight, and it is impossible from the field of operation to distribute 30% of the weight or more of a graphite powder also in distributed casting, and in order to demonstrate low-fever expansibility peculiar to the above graphites, and high-temperature-strength nature, it runs short quantitatively.
[0005] in order [on the other hand,] to suppress deformation by the thermal expansion and contraction of a piston to JP,62-294751,A and to improve intensity -- the substantia compacta or a porosity graphite annular Plastic solid -- the piston made from an aluminium alloy -- ******** -- the piston for internal combustion engines of the multicomputer system which reinforces a part is proposed by things, and the sinking-in processing by the high pressure casting process is shown as an insert means however, this piston makes a graphite annular solid placed between specific parts as partial reinforcing materials, and the circumference is ******** in an aluminium alloy -- since structure is presented, the amount of the

graphite which the subject of the quality of the material is a product made from an aluminium alloy to the last, and is occupied to a component is not a ratio to the extent that the low-fever expansibility and the high temperature strength of the whole piston are improved
[0006]
[Problem(s) to be Solved by the Invention] the result which repeated research many-sided about the quality-of-the-material conditions of the piston material which demonstrates an effective property peculiar to a graphite to the maximum extent, without this invention's raising the graphite ratio in a multicomputer system compared with the conventional technology, and spoiling quality-of-the-material intensity -- the multicomputer system composition row of the graphite of the suitable range, and an aluminium alloy -- a character is solved and it results in development
[0007] That is, the purpose of this invention is lightweight and is in the place which is going to offer the material for pistons and its manufacture method of the graphite-aluminium alloy multicomputer system which combines low thermal-expansion nature and the outstanding quality-of-the-material strength property.
[0008]
[Means for Solving the Problem] the volume ratio of the graphite which the material for pistons of this invention for attaining the above-mentioned purpose is the multicomputer system quality of the material in which the aluminium alloy carried out distributed mediation at the pore in-house of isotropic graphite material, and is occupied in this multicomputer system quality of the material -- 60 - 95% of range -- it is -- and the porosity of the quality of the material -- 10% or less of composition -- it is characterized [constitutional] by having a character
[0009] The isotropic graphite material which constitutes the piston material of this invention means the graphite material of the organization for which which mechanical, thermal, and electric property shows isotropy in all the directions of material, and usually points out what has the ratio (different direction ratio) of the maximum at the time of measuring a coefficient of thermal expansion, specific resistance, a mechanical strength, etc., and the minimum value in the range of 1.0-1.1. On the other hand, the thing of the composition in which alloy contents, such as copper, magnesium, manganese, nickel, silicon, and zinc, contain the aluminium alloy in at least one or more sorts and 0.2 - 13% of the weight of the range is compounded suitably. These multicomputer system quality of the materials need to be the gestalten with which the aluminium alloy carried out distributed mediation and was filled up into the pore in-house of isotropic graphite material precisely and stably, and the purpose of this invention is not attained with the structure where the graphite and the aluminium alloy were compounded by distribution, junction, or the insert.
[0010] composition of such the multicomputer system quality of the material -- the volume ratio of 60 - 95% of range and an aluminium alloy having as a character the volume ratio of the graphite occupied in the quality of the material in 5 - 40% of range and being [the porosity of the quality of the material / 10% or less] ** become the important requirements for this invention When it becomes impossible to raise a high temperature strength and 95% is exceeded, the compound function by the aluminium alloy is not demonstrated, but it becomes impossible to obtain quality-of-the-material intensity sufficient as a material for pistons, in the volume ratio of a graphite not falling 60% effectively [lower ****, density, and coefficient of thermal expansion]. Moreover, if distributed mediation of the aluminium alloy to the pore organization of isotropic graphite material is inadequate and the porosity of the quality of the material comes to exceed 10%, quality-of-the-material intensity comes to run short. Although desirable quality-of-the-material porosity is 0%, 10% can permit it.
[0011] the above-mentioned composition -- the material for pistons equipped with a character can manufacture the molten metal of an aluminium alloy to the isotropic graphite material of 5 - 40% of porosity by the method of carrying out pressurization sinking in under a two or more 100 kg/cm pressure

[0012] The reason for using the isotropic graphite material of 5 - 40% of porosity as a base material is that it becomes the indispensable requirements for holding the bulk density, coefficient of thermal expansion, and high temperature strength of the multicomputer system material from which the porosity

of this range is finally obtained to the level suitable as a material for pistons. That is, sinking [of the aluminium alloy to the pore in-house section] in will not advance smoothly that base-material porosity is less than 5%, quality-of-the-material intensity declines, if another side and 40% are exceeded, the rate of impregnation of an aluminium alloy will become high too much, bulk density and coefficient of thermal expansion will rise, and the result to which a high temperature strength falls simultaneously is caused.

[0013] The isotropic graphite material which has 5 - 40% of these porosity can be manufactured by controlling grain refining of an aggregated particle, a process condition, the conditions of graphitization, etc. in the method of back-baking-carbonizing and graphitization processing which fabricated the aggregated particle which pulverized the kneading object of a fines-like coke breeze and a tar pitch in the predetermined configuration by the rubber press.

[0014] Pressurization sinking-in processing is immersed into the aluminum molten metal held in the isotropic graphite material used as a base material at 650-900 degrees C, and is performed at the process which gives a pressurization state using gas pressurization or a liquid-metal-forging means. Under the present circumstances, as for isotropic graphite material, it is desirable to process the configuration where the target piston was met beforehand and to preheat to an aluminium alloy molten metal and this temperature in a vacuum or inert gas atmosphere before being immersed. It becomes impossible to set the pressure at the time of sinking in as two or more 100 kg/cm, and for this to advance sinking in smoothly in lower **** pressurization.

[0015] It pulls up from an aluminum molten metal, and cools, and the isotropic graphite material after sinking-in processing carries out cutting of the unnecessary aluminium alloy which adhered to the front face if needed, and obtains the material for pistons.

[0016]

[Function] the volume ratio of the graphite which the material for pistons of this invention is the multicomputer system quality of the material in which the aluminium alloy carried out distributed mediation at the pore in-house of isotropic graphite material, and is occupied in this multicomputer system quality of the material -- 60 - 95% of range -- it is -- and the porosity of the quality of the material -- 10% or less of composition -- it has a character Therefore, a composition subject is the isotropic graphite material used as a skeleton base material, and is presenting the composite construction by which was precise and homogeneous restoration was stably carried out so that an aluminium alloy might become 5 - 40% of volume ratio in the pore in-house section. In this multicomputer system, the isotropic graphite material by which skeleton formation is carried out fully demonstrates low density peculiar to the quality of the material, low-fever expansibility, and a high-temperature-strength property in 60 - 95% of volume-ratio range, and the aluminium alloy which carried out distributed mediation at the pore in-house functions in order to reinforce isotropic graphite material and to pull up quality-of-the-material intensity excellently. It acts in multiplication, and these performance grant functions have the quality-of-the-material [which is required of the material for pistons] intensity which was lightweight and was excellent with low thermal-expansion nature, and are given with firmly and sufficient balance of the performance of right sliding nature.

[0017] Moreover, if the manufacture method of this invention is followed, it will become possible to produce industrially efficiently the material for pistons which equips the isotropic graphite material of 5 - 40% of porosity with the above-mentioned highly efficient complex tissue according to the comparatively easy process of carrying out pressurization sinking in of the molten metal of an aluminium alloy.

[0018]

[Example] Hereafter, the example of this invention is explained as contrasted with the example of comparison.

[0019] One to example 1 and example of comparison 2 1.85g [/cc] bulk density and the isotropic graphite material [the Tokai Carbon Co., Ltd. make and G347] of 18.1% of porosity were processed with a diameter [of 80mm], and a length of 100mm in the shape of a pillar, and it considered as the base material. This base material was preheated at 700 degrees C in the vacuum, and it was immersed

into the molten metal of the aluminium alloy (AC8A) which carried out vacuum heating within the sealing system similarly, and was held at the temperature of 700 degrees C. Subsequently, argon gas was introduced in the system, the ambient-pressure force was gone up to 110 kg/cm2, and pressurization sinking-in processing was performed. The base material after sinking in was pulled up from the molten metal, it cooled, and the composite was obtained. The volume ratio of the graphite occupied to this composite was 81.9%.

[0020] When the cross-section organization of the obtained composite was investigated, filling up with the aluminium alloy homogeneously to the interior of a pore organization was checked. The piece of a trial with a diameter [of 10mm] and a length of 60mm (five pieces) is started from the length direction and the direction of a path of this material, and they are bulk density and porosity with the Archimedes method SiO2 The coefficient of thermal expansion (50-300 degrees C) was measured with the comparison method, respectively. Moreover, ordinary temperature and hot (350-degree-C o'clock) flexural strength were measured by the three-point bending method of span 50mm and test-period 0.5 mm/min. Those results were shown in Table 1. In addition, it carried jointly in Table 1 also about the property of the isotropic graphite material (example 1 of comparison) used for the base material for comparison, and aluminium alloy material (example 2 of comparison).

[0021]

[Table 1]

例No.	測定材料	嵩密度 (g/cc)	気孔率 (%)	曲げ強度 (MPa)		熱膨張係数 ($\times 10^{-6}$／℃)
				常 温	高 温	
実施例1	長さ方向	2.25	0.0	175	120	6.7
	径方向	2.26	0.0	178	118	6.5
比較例1	黒鉛基材	1.85	10.5	60	60	4.0
〃 2	Ａ１合金	2.68	0.0	410	58	20.4

[0022] From the result of Table 1, the multicomputer system quality of the material by the example has a relatively low coefficient of thermal expansion in a bulk density row compared with aluminum alloy, compared with the graphite base material and aluminum alloy, the good property of the balance ordinary temperature and whose elevated-temperature flexural strength improved sharply is shown, and the performance requirements required of the material for pistons are fulfilled.

[0023] The isotropic graphite material from which three to examples 2-6 and example of comparison 5 bulk density, porosity, etc. differ was made into the base material, the flow and pressure requirement was changed, sinking-in processing by the same aluminium alloy molten metal as an example 1 was carried out, and the material for pistons of the multicomputer system from which the graphite volume ratio and porosity which are occupied in the quality of the material are different was manufactured. Various properties were measured like the example 1 per [which was obtained] each compound material, and the result was made to contrast with a graphite volume ratio and quality-of-the-material porosity, and was shown in Table 2.

[0024]

[Table 2]

例No.	黒鉛の体積比	材質の気孔率 (%)	嵩密度 (g/cc)	曲げ強度(MPa)		熱膨張係数 ($\times 10^{-6}$ /℃)
				常 温	高 温	
実施例 2	60	0.0	2.43	283	108	7.2
〃 3	72	1.6	2.33	218	120	6.9
〃 4	84	0.3	2.31	230	124	6.4
〃 5	95	0.4	2.26	205	106	5.4
比較例 3	70	11.5	2.34	88	73	7.2
〃 4	55	0.0	2.45	290	77	11.1
〃 5	40	12.0	2.20	175	41	13.8

[0025] composition of Table 2 to this invention -- in the examples 3-5 of comparison which separate from the limited requirements for this invention in the examples 2-5 with which a character is filled although the compound property which has the ordinary temperature and elevated-temperature flexural strength which were lightweight and were excellent with the low coefficient of thermal expansion was shown, the decrement result incongruent as a material for pistons was accepted in one of compound properties

[0026] The isotropic graphite material (the diameter of 80mm, a length of 100mm) from which examples 6-9, the example 6 of comparison - 10 base-material porosity differ was preheated in temperature of 650 degrees C in argon gas atmosphere, it set to metal mold, the 800-degree C aluminium alloy (AC8A) was poured in immediately, and the base material was immersed. subsequently, metal mold -- giving the pressure of 500 kg/cm2 to punch, it held for 2 minutes and cooled After carrying out cutting removal of the excessive aluminium alloy adhering to the front face of the obtained composite, various properties were measured like the example 1. It was shown in drawing 1 and drawing 2 by making the result into a graph. Drawing 1 is the related view of base-material porosity and a composite coefficient of thermal expansion, and drawing 2 is a related view with bulk density at the elevated-temperature flexural strength row of base-material porosity and a composite.

[0027] From drawing 1 , in the range whose porosity of the used base material is 5 - 40%, although a coefficient of thermal expansion fixed as a composite property at lower order is obtained, if base-material porosity exceeds 40%, the inclination for a coefficient of thermal expansion to rise rapidly will be accepted. Moreover, the graph of drawing 2 was increasing in the range whose elevated-temperature flexural strength of a composite is 5 - 40% of base-material porosity, and although bulk density went up as base-material porosity became high, in the field whose base-material porosity is 5 - 40%, that it is in the lightweight range which can be permitted made it clear.

[0028]

[Effect of the Invention] It becomes it is lightweight and possible by making isotropic graphite material into a skeleton base material according to this invention, sinking in an aluminium alloy and forming the organization of a distributed multicomputer system as above, so that a specific volume ratio and specific porosity may be filled to this to offer the material for pistons which combines low thermal-expansion nature and the outstanding quality-of-the-material intensity. Therefore, it is very useful as a material for the internal combustion engine piston for heavy loads asked for performances, such as low mpg, high power, and low noise.

[Translation done.]

* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] the volume ratio of the graphite which is the multicomputer system quality of the material in which the aluminium alloy carried out the distributed intervention at the pore in-house of isotropic graphite material, and is occupied in this multicomputer system quality of the material -- 60 - 95% of range -- it is -- and the porosity of the quality of the material -- 10% or less of composition -- the material for pistons characterized by having a character
[Claim 2] The manufacture method of the material for pistons characterized by carrying out pressurization sinking in of the molten metal of an aluminium alloy under a two or more 100 kg/cm pressure at the isotropic graphite material of 5 - 40% of porosity.

[Translation done.]

AM

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(54) **BASE MATERIAL FOR PISTON AND PRODUCTION THEREOF**

(57) Abstract:

PURPOSE: To provide a graphite-aluminum alloy composite series base material for piston and a manufacturing method thereof having light wt. and providing low thermal expansion and also excellent material strength characteristic.

CONSTITUTION: This base material for piston is the graphite-aluminum series material dispersing the aluminum alloy in porous structure of isotropic graphite material and has the vol. ratio of the graphite possessed in this composite series material in the range of 60-95% and provides composition characteristic of 210% porosity of this material. In this method for manufacturing the base material for piston, the molten aluminum alloy is pressurized and impregnated to the isotropic graphite material having 5-40% porosity at ³100kg/cm^2 pressure.

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(54)【発明の名称】ピストン用素材とその製造方法

(57)【要約】

【目的】　軽量で低い熱膨張性と優れた材質強度特性を兼備する黒鉛－アルミニウム合金複合系のピストン用素材とその製造方法を提供する。

【構成】　等方性黒鉛材の気孔組織内にアルミニウム合金が分散介在した複合系材質であって、その複合系材質中に占める黒鉛の体積比が６０～９５％の範囲にあり、かつ材質の気孔率が１０％以下の組成性状を備えるピストン用素材。このピストン用素材を製造する方法は、気孔率５～４０％の等方性黒鉛材に、アルミニウム合金の溶湯を１００kg/cm² 以上の圧力下で加圧含浸することを特徴としている。

1

【特許請求の範囲】

【請求項１】　等方性黒鉛材の気孔組織内にアルミニウム合金が分散介在した複合系材質であって、該複合系材質中に占める黒鉛の体積比が６０～９５％の範囲にあり、かつ材質の気孔率が１０％以下の組成性状を備えることを特徴とするピストン用素材。

【請求項２】　気孔率５～４０％の等方性黒鉛材に、アルミニウム合金の溶湯を１００kg/cm²以上の圧力下で加圧含浸することを特徴とするピストン用素材の製造方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、軽量で低い熱膨張性と優れた材質強度を兼備する内燃機関のピストン用素材とその製造方法に関する。

【０００２】

【従来の技術】比較的多量の珪素成分を含むＡｌ－Ｓｉ系のアルミニウム合金（ＪＩＳ　ＡＣ８Ａ、Ａ４０３２等）は軽量で低熱膨張率を有しているため、従来から内燃機関のピストン用素材として多用されている。しかし、近年、ピストン部材には低燃費化、高出力化、低騒音化などを対象とした一層厳しい性能付与が要求されており、これに伴って機関内の温度や回転数が高まることからアルミニウム合金製のピストン素材では特性的に対応が困難となっている。

【０００３】黒鉛は、低密度で熱膨張率が小さく、潤滑性があって高温下でも強度低下を生じないというピストン用素材に好適な固有の特性を備えているが、材質強度そのものは金属材料に比べて格段に低いという致命的な欠点がある。このため、黒鉛単体としてピストン用素材に適用された例はないが、その固有の特性を利用して金属材料と複合化させることによりピストン性能の改善を図る手段については多くの研究がなされている。

【０００４】金属材料をアルミニウム合金とした典型的な複合系には、例えば特開平１－132736号公報に記載されているようなアルミニウム合金粉末に黒鉛粉末を混合して焼結する方法（粉末焼結法）または特開昭57－124564号公報に開示されているアルミニウム合金の溶湯に黒鉛粉末を分散させて鋳造する方法（分散鋳造法）がある。ところが、これら方法は黒鉛粉末の添加によりアルミニウム合金のピストン素材に潤滑性を与えることを主要な目的とするものであって、黒鉛の低熱膨張性や高温強度に着目されたものではない。因みに、粉末焼結法における黒鉛粉末添加量の限界は５重量％程度であり、また分散鋳造法においても３０重量％以上の黒鉛粉末を分散させることは操作の面から不可能であり、前記のような黒鉛固有の低熱膨張性や高温強度性を発揮させるためには量的に不足する。

【０００５】これに対し、特開昭62－294751号公報にはピストンの熱膨張・収縮による変形を抑え、かつ強度を

2

改良するために、緻密質または多孔質黒鉛環状成形体をアルミニウム合金製ピストンに鋳ぐるむことによって一部を補強する複合系の内燃機関用ピストンが提案されており、鋳ぐるみ手段として高圧鋳造法による含浸処理が示されている。しかしながら、このピストンは特定箇所に黒鉛環状体を部分的な補強材として介在させ、その周囲はアルミニウム合金で鋳ぐるんだ構造を呈しているから、材質の主体はあくまでもアルミニウム合金製であって構成材料に占める黒鉛の量はピストン全体の低熱膨張性や高温強度を改善するほどの比率ではない。

【０００６】

【発明が解決しようとする課題】本発明は、従来技術に比べて複合系における黒鉛比率を高め、材質強度を損ねずに黒鉛固有の有効特性を最大限に発揮させるピストン素材の材質条件について多角的な研究を重ねた結果、好適な範囲の黒鉛とアルミニウム合金の複合系組成ならび性状を解明して開発に至ったものである。

【０００７】すなわち、本発明の目的は、軽量で低い熱膨張性と優れた材質強度特性を兼備する黒鉛－アルミニウム合金複合系のピストン用素材およびその製造方法を提供しようとするところにある。

【０００８】

【課題を解決するための手段】上記の目的を達成するための本発明のピストン用素材は、等方性黒鉛材の気孔組織内にアルミニウム合金が分散介在した複合系材質であって、該複合系材質中に占める黒鉛の体積比が６０～９５％の範囲にあり、かつ材質の気孔率が１０％以下の組成性状を備えることを構成上の特徴とする。

【０００９】本発明のピストン素材を構成する等方性黒鉛材とは、材料の全方向において機械的、熱的、電気的などの特性が等方性を示す組織の黒鉛材料を意味し、通常、熱膨張係数、固有抵抗、機械的強度等を測定した際の最大値と最小値の比（異方比）が１．０～１．１の範囲にあるものを指す。一方、アルミニウム合金は、例えば銅、マグネシウム、マンガン、ニッケル、珪素、亜鉛等の合金成分が少なくとも１種以上、０．２～１３重量％の範囲で含有されている組成のものが好適に複合される。これらの複合系材質は、等方性黒鉛材の気孔組織内にアルミニウム合金が分散介在して緻密かつ安定に充填された形態である必要があり、分散、接合あるいは鋳ぐるみ等によって黒鉛とアルミニウム合金を複合させた構造では本発明の目的は達成されない。

【００１０】このような複合系材質の組成性状として、その材質中に占める黒鉛の体積比が６０～９５％の範囲、アルミニウム合金の体積比が５～４０％の範囲にあること、および材質の気孔率が１０％以下であること、が本発明の重要な要件となる。黒鉛の体積比が６０％を下廻ると密度および熱膨張率が効果的に低下しないうえ、高温強度を向上させることができなくなり、９５％を越えるとアルミニウム合金による複合機能が発揮され

ず、ピストン用素材として十分な材質強度を得ることができなくなる。また、等方性黒鉛材の気孔組織に対するアルミニウム合金の分散介在が不十分で材質の気孔率が１０％を越えるようになると、材質強度が不足するようになる。好ましい材質気孔率は０％であるが、１０％までは許容できる。

【００１１】上記の組成性状を備えるピストン用素材は、気孔率５～４０％の等方性黒鉛材に、アルミニウム合金の溶湯を１００kg/cm²以上の圧力下で加圧含浸する方法で製造することができる。

【００１２】基材として気孔率５～４０％の等方性黒鉛材を使用する理由は、この範囲の気孔率が最終的に得られる複合系材料の嵩密度、熱膨張係数および高温強度をピストン用素材として好適な水準に保持するための必須の要件となるからである。すなわち、基材気孔率が５％未満であると気孔組織内部へのアルミニウム合金の含浸が円滑に進行しなくなって材質強度が減退し、他方、４０％を越えるとアルミニウム合金の含浸率が高くなり過ぎて嵩密度、熱膨張率が上昇し、同時に高温強度が低下する結果を招く。

【００１３】かかる気孔率５～４０％を有する等方性黒鉛材は、微粉状のコークス粉とタールピッチの混練物を微粉砕した二次粒子をラバープレスにより所定形状に成形したのち焼成炭化および黒鉛化処理する方法において、二次粒子の粒度調整、成形条件、黒鉛化の条件などを制御することによって製造することができる。

【００１４】加圧含浸処理は、基材となる等方性黒鉛材を６５０～９００℃に保持されたアルミニウム溶湯中に浸漬し、ガス加圧もしくは溶湯鍛造手段を用いて加圧状態を付与する工程でおこなわれる。この際、等方性黒鉛材は予め目的とするピストンに沿った形状に加工し、浸漬前に真空中または不活性ガス雰囲気中でアルミニウム合金溶湯と同温度に予熱しておくことが好ましい。含浸時の圧力は１００kg/cm²以上に設定する必要があり、これを下廻る加圧では円滑に含浸を進行させることができなくなる。

【００１５】含浸処理後の等方性黒鉛材はアルミニウム溶湯から引上げて冷却し、必要に応じて表面に付着した不要のアルミニウム合金を切削加工してピストン用素材を得る。

【００１６】

【作用】本発明のピストン用素材は、等方性黒鉛材の気孔組織内にアルミニウム合金が分散介在した複合系材質であって、該複合系材質中に占める黒鉛の体積比が６０～９５％の範囲にあり、かつ材質の気孔率が１０％以下

の組成性状を備える。したがって、構成主体は骨格基材となる等方性黒鉛材であり、その気孔組織内部にアルミニウム合金が５～４０％の体積比になるように緻密で安定的に均質充填された複合構造を呈している。この複合系において、骨格形成されている等方性黒鉛材は６０～９５％の体積比範囲で材質固有の低密度、低熱膨張性および高温強度特性を十分に発揮し、気孔組織内に分散介在したアルミニウム合金は等方性黒鉛材料を補強して材質強度を高水準に引き上げるために機能する。これらの性能付与機能が相乗的に作用して、ピストン用素材に要求される軽量で低い熱膨張性と優れた材質強度を兼備し、強固で良摺動性の性能がバランスよく付与される。

【００１７】また、本発明の製造方法に従えば、気孔率５～４０％の等方性黒鉛材にアルミニウム合金の溶湯を加圧含浸するという比較的簡単なプロセスにより、上記した高性能の複合組織を備えるピストン用素材を工業的に効率よく生産することが可能となる。

【００１８】

【実施例】以下、本発明の実施例を比較例と対比して説明する。

【００１９】実施例１、比較例１～２

嵩密度１．８５g/cc、気孔率１８．１％の等方性黒鉛材〔東海カーボン（株）製、Ｇ３４７〕を直径８０mm、長さ１００mmの円柱状に加工して基材とした。この基材を真空中で７００℃に予熱し、同様に密閉系内で真空加熱して７００℃の温度に保持されたアルミニウム合金（ＡＣ８Ａ）の溶湯中に浸漬した。ついで系内にアルゴンガスを導入し、雰囲気圧力を１１０kg/cm²に上昇して加圧含浸処理をおこなった。含浸後の基材を溶湯から引上げ、冷却して複合材を得た。この複合材に占める黒鉛の体積比は、８１．９％であった。

【００２０】得られた複合材の断面組織を調査したところ、気孔組織の内部までアルミニウム合金が均質に充填されていることが確認された。この材料の長さ方向および径方向から直径１０mm、長さ６０mmの試片（５個）を切り出し、アルキメデス法で嵩密度および気孔率を、SiO_2との比較法で熱膨張係数（５０～３００℃）をそれぞれ測定した。また、スパン５０mm、試験速度０．５mm/minの３点曲げ法により常温および高温（３５０℃時）の曲げ強度を測定した。それらの結果を、表１に示した。なお、比較のために、基材に用いた等方性黒鉛材（比較例１）およびアルミニウム合金材（比較例２）の特性についても表１に併載した。

【００２１】

【表１】

例No.	測定材料	嵩密度 (g/cc)	気孔率 (%)	曲げ強度 (MPa) 常温	曲げ強度 (MPa) 高温	熱膨張係数 (×10⁻⁶/℃)
実施例１	長さ方向	2.25	0.0	175	120	6.7
	径方向	2.26	0.0	178	118	6.5
比較例１	黒鉛基材	1.85	10.5	60	60	4.0
〃 ２	Ａ１合金	2.68	0.0	410	58	20.4

【００２２】表１の結果から、実施例による複合系材質はＡ１合金材に比べて相対的に嵩密度ならびに熱膨張係数が低く、黒鉛基材、Ａ１合金に比べ常温および高温曲げ強度が大幅に向上したバランスのよい特性を示しており、ピストン用素材に要求される性能要件を満たしている。

【００２３】実施例２～６、比較例３～５

嵩密度、気孔率などが異なる等方性黒鉛材を基材とし、実施例１と同様のアルミニウム合金溶湯による含浸処理を圧力条件を変えて実施して、材質に占める黒鉛体積比および気孔率が相違する複合系のピストン用素材を製造した。得られた各複合素材につき実施例１と同様にして各種特性を測定し、結果を黒鉛体積比および材質気孔率と対比させて表２に示した。

【００２４】

【表２】

例No.	黒鉛の体積比	材質の気孔率 (%)	嵩密度 (g/cc)	曲げ強度(MPa) 常温	曲げ強度(MPa) 高温	熱膨張係数 (×10⁻⁶/℃)
実施例２	60	0.0	2.43	283	108	7.2
〃 ３	72	1.6	2.33	218	120	6.9
〃 ４	84	0.3	2.31	230	124	5.4
〃 ５	95	0.4	2.26	205	106	5.4
比較例３	70	11.5	2.34	88	73	7.2
〃 ４	55	0.0	2.45	290	77	11.1
〃 ５	40	12.0	2.20	175	41	13.8

【００２５】表２から、本発明の組成性状を満たす実施例２～５では軽量で低い熱膨張係数と優れた常温および高温曲げ強度を兼備する複合特性を示したが、本発明の限定要件を外れる比較例３～５ではいずれかの複合特性にピストン用素材として不適合の減退結果が認められた。

【００２６】実施例６～９、比較例６～10

基材気孔率の異なる等方性黒鉛材（直径８０㎜、長さ１００㎜）をアルゴンガス雰囲気中で６５０℃の温度に予熱して金型にセットし、直ちに８００℃のアルミニウム合金（ＡＣ８Ａ）を注入して基材を浸漬した。ついで、金型パンチに５００kg/cm²の圧力を付与しながら２分間保持し、冷却した。得られた複合材の表面に付着した余分のアルミニウム合金を切削除去したのち、実施例１と同様にして各種特性を測定した。その結果をグラフとして図１および図２に示した。図１は基材気孔率と複合材熱膨張係数との関係図であり、図２は基材気孔率と複合材の高温曲げ強度ならびに嵩密度との関係図である。

【００２７】図１からは、用いた基材の気孔率が５～４０％の範囲では複合材特性として低位で一定の熱膨張係数が得られるが、基材気孔率が４０％を越えると熱膨張係数が急激に上昇する傾向が認められる。また、図２のグラフは複合材の高温曲げ強度が基材気孔率５～４０％の範囲で増大しており、嵩密度は基材気孔率が高くなるに従って上昇するが基材気孔率が５～４０％の領域では許容しえる軽量範囲にあることが判明した。

【００２８】

【発明の効果】以上のとおり、本発明によれば等方性黒鉛材を骨格基材とし、これに特定の体積比と気孔率を満たすようにアルミニウム合金を含浸して分散複合系の組織を形成することにより、軽量で低い熱膨張性と優れた材質強度を兼備するピストン用素材を提供することが可能となる。したがって、低燃費、高出力、低騒音等の性能が求められる高負荷用の内燃機関ピストンを対象とし

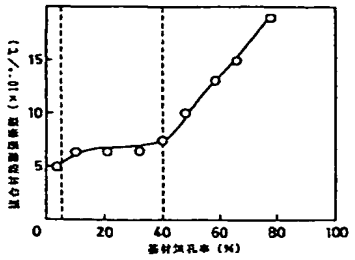
7

た素材として極めて有用である。

【図面の簡単な説明】

【図１】実施例と比較例による基材気孔率と複合材熱膨張係数の関係を示したグラフである。

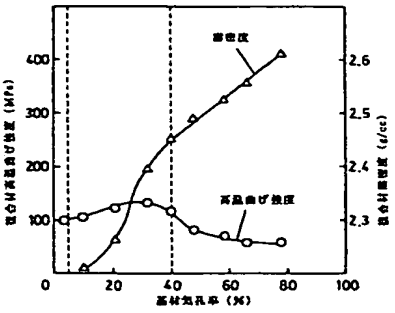
【図１】



8

【図２】実施例と比較例による基材気孔率と複合材の高温曲げ強度ならびに嵩密度との関係を示したグラフである。

【図２】



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